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Autostereoscopic displays based on liquid crystal microlenses

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Keywords: Liquid crystals, autostereoscopic imaging, micro-optical elements.

Abstract

Three-dimensional vision has acquired great importance in audiovisual industry in the past ten years. Despite this, the first generation of autostereoscopic displays failed to generate enough consumer excitement. Some reasons are few 3D content and performance issues. For this reason, an exponentially increase in three-dimensional vision research has been produced in the last few years. The use of microlenses seem to be the most successful method to obtain autostereoscopic vision. When they are fabricated with liquid crystal materials extended capabilities are produced [1].

Liquid crystals (LCs) have been the subject of numerous developments during the past 50 years. In some areas have competed with other materials, but in other cases, their anisotropic properties easily modifiable through the application of external fields (mechanical, electric or magnetic) are unique. Therefore, now and in the future LCs will be the protagonists of a multitude of applications, mostly non-related with displays (LCDs). Today, there are wide variety of research lines open. For example, optical communications, microwave and terahertz, nanotechnology, medicine, biology and biochemistry, security, sensors and optical phase modulators.

In this presentation, three devices based on liquid crystal materials has been designed and manufactured in order to create advanced autoestereoscopic devices for mobile applications and Integral Imaging. The first one is used in a tunable autostereoscopic device. It could also be used as an aberrator compensator in this type of devices. The second one, is an InI capture system. Finally, the third device can be used either as a rotary cylindrical microlens array or as a spherical microlens array with full fill factor.

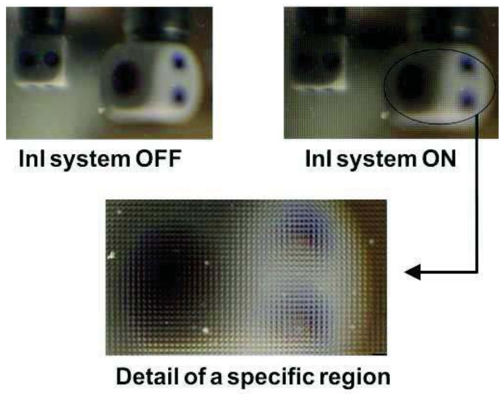

Fig. 1. Tunable Integral Imaging capture system based on liquid crystal microlenses.

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[2] J. F. Algorri, V. Urruchi, J. M. Sánchez-Pena, J. M Otón, "An Autostereoscopic Device for Mobile Applications Based on a Liquid Crystal Microlens Array and an OLED Display," J. Disp. Technol., vol. 46, no. 4, pp. 327-336 (2014).
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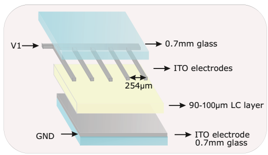
Abstract:

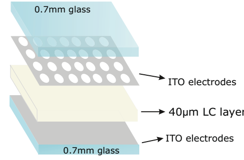
Three-dimensional vision has acquired great importance in audiovisual industry in the past ten years. Despite this, the first generation of autostereoscopic displays failed to generate enough consumer excitement. Some reasons are few 3D content and performance issues. For this reason, an exponentially increase in three-dimensional vision research has been produced in the last few years. The use of microlenses seem to be the most successful method to obtain autostereoscopic vision. When they are fabricated with liquid crystal materials extended capabilities are produced [1]. In this presentation, three devices has been designed and manufactured in order to create advance autoestereoscopic devices for mobile applications and Integral Imaging. The first one is used in a tunable autostereoscopic device. It could be also used as an aberrator compensator in this type of devices. The second one is an InI capture system. Finally, the third device can be used as a rotary cylindrical microlens array or as a spherical microlens array with full fill factor.

Devices

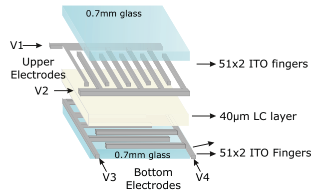
Device 1



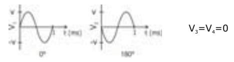
Device 2



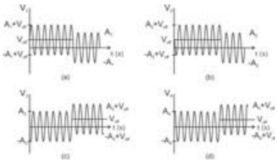
Device 3



Device 3 (a)

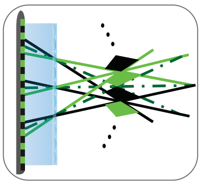


Device3 (b)

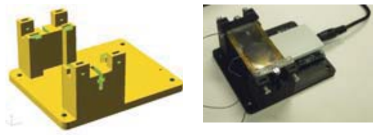


Applications

Device 1 Autostereoscopic Device [2]

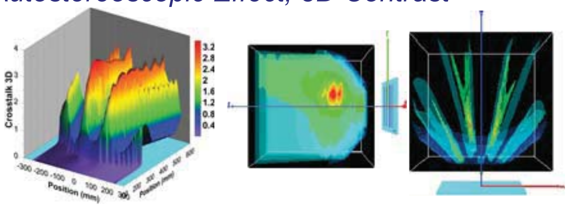


Working Principle



A lenticular positioner has been designed with OpenSCAD and realized with a 3D printer.

Autostereoscopic Effect, 3D Contrast

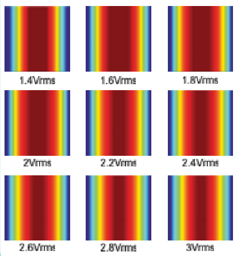


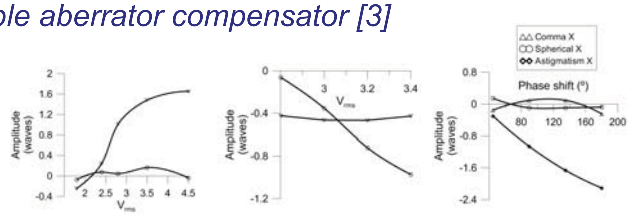
Flip Effect, two views at different angles

GDAF VIDEO

With an interlaced image and a digital camera situated at different angles, two different images can be observed.

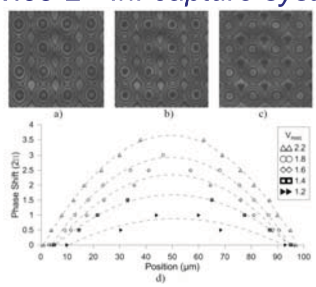
Device 1 Tunable aberrator compensator [3]





In this device, some aberration coefficients can be independently tuned by using different strategies in the applied voltage. It can be considered as an aberration compensation device for rectangular micro-apertures.

Device 2 InI capture system [4]

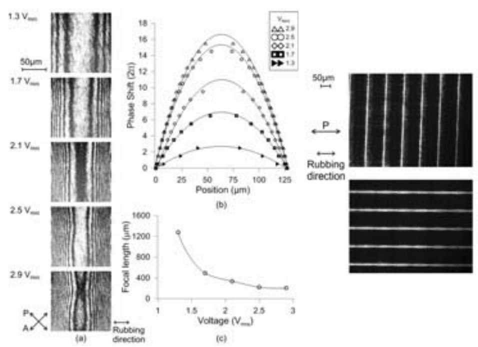


Example of a captured fringe patterns and phase profiles.

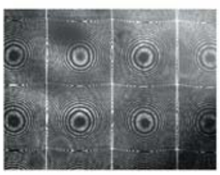
InI system OFF **InI system ON**

Detail of a specific region

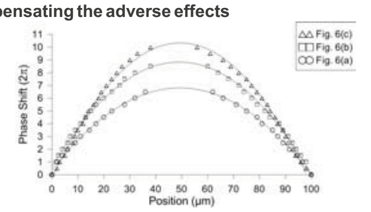
Device 3 (a) Rotary [5] and (b) full fill factor microlenses [6]



Rotation capability of the cylindrical lens: Posible switch of the autostereoscopic image in a mobile phone (vertical and horizontal position)



.Experimental interference fringes after compensating the adverse effects



The square aperture, high optical power and fill factor makes this device a good candidate for the next generation of autostereoscopic devices based on InI technique.

Conclusions:

- An autostereoscopic prototype based on OLED display, LC microlenses and a lenticular positioner has been designed and manufactured.
- Optical aberrations have been modelled and measured in an LC cylindrical microlens for the first time. LC cylindrical lenses are suggested as aberration compensation devices. The aberrations can be independently controlled by different techniques.
- A tunable InI capture system is demonstrated.
- A micro-optical array with rotary axis and tunable phase was proposed and experimentally demonstrated. This device could be useful for the rotation between horizontal and vertical modes in mobile phones with autoestereoscopic capabilities.
- A LC microlens array with high optical power and nearly 100% of fill-factor has been proposed and experimentally demonstrated.
- The square aperture, high optical power and fill factor makes this device a good candidate for the next generation of autostereoscopic devices based on InI technique.

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